UNDERGROUND INJECTION CONTROL PERMIT APPLICATION FOR CLASS I NON-HAZARDOUS INJECTION WELLS

Elk Hills Power, LLC
SW/4 Section 18G, T31S, R24E
Kern County, California

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TABLE OF CONTENTS

UNDERGROUND INJECTION CONTROL PERMIT APPLICATION FOR CLASS I NON-HAZARDOUS INJECTION WELLS

LIST OF EXHIBITS

LIST OF EXHIBITS (Cont'd)

LIST OF SUPPORTING DOCUMENTATION (on CD-Rom)

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SUMMARY

Introduction

The Elk Hills Power (EHP) facility is located on 4026 Skyline Road in Tupman, California approximately 25 miles southwest of Bakersfield, California. The 550 megawatt power plant is one of the cleanest and most efficient natural-gas fueled power plants in the nation. It is capable of generating enough electricity for about 420,000 homes in the area. The plant is owned and operated by Occidental Elk Hills Inc. (OEHI). It is located in western Kern County on a 12 acre parcel of land situated in the middle of Occidental's Elk Hills oil and gas field.

The Elk Hills Power project was brought on line in July 2003. The power plant consists of two combustion turbine generators, two heat recovery steam generators and exhaust stacks, and one steam turbine. Natural gas is supplied by a pipeline owned and operated by OEHI. Process water is provided by the West Kern Water District (WKWD) and transported to the plant by a 10-mile, 16-inch supply pipeline.

Non-hazardous wastewater is disposed of in four Class I disposal wells located four miles south of the power plant site (**Exhibit B-1**). The wastewater consists of turbine wash wastewater; cooling tower blowdown wastewater (using source water from West Kern Water District); plant area wash wastewater; demineralizer resins regeneration wastewater; plant and equipment drains wastewater; filter backwash wastewater; and non-oil-contaminated storm runoff wastewater. The disposal wells were permitted initially under EPA UIC Permit No. CA200002 issued on February 21, 2001.

Four disposal wells were drilled in 2002 and 2003. They began operation in July 2003 and have performed as designed without incident over the past eight years. The total cumulative wastewater injection was 27,607,262 barrels as of December 31, 2010. Operating data and formation testing results are described in **Attachments H** and **I**. Recently, one of the disposal wells, 25-18G, was plugged and abandoned.

This permit application seeks to re-permit the existing three (3) Class I wells for continued disposal of the EHP non-hazardous wastewater. The original EPA UIC permit (#CA200002) had a term of 10 years. Disposal injection is at depths of 700 to 1400 feet into the Tulare geologic formation at average rates of 200 to 300 gallons per minute (7,000 to 10,000 barrels per day). This application submittal follows the regulations in 40 CFR parts 144-146 and responds to various guidance documents and review letters prepared by or for the U.S. EPA Region 9 office.

Area of Review

The Area of Review (AOR) is the radius around the injection wells which may be impacted from wastewater disposal. The area of review in the original EHP application for this project was a 0.5-mile radius around each injection well. For this permit re-application, two methods were used to calculate the potential AORs based on the cumulative injection to-date and with a prediction of the extension of the radius over the next ten years. The pressure front calculations and water front radius calculations projected over the next 10 years are discussed in **Exhibit A**. These calculations indicate that an AOR of 0.5 mile fixed radius around the injection site is reasonable.

There are 17 wells located within the defined AOR according to the California Division of Oil, Gas and Geothermal Resources (DOGGR). These wells are shown on the base map in **Exhibit B-3**. Of the 17 wells, nine wells are active water disposal wells and the remaining eight wells are plugged and abandoned. The well information for all wells in the AOR that penetrate the target injection zone is given by **Exhibit C-1**.

Underground Source of Drinking Water (USDW)

There are no underground sources of drinking water within the area of review (**Attachment B**). In addition, the Tulare injection formation is not an USDW within the project area and is not reasonably expected to supply a public water system within the project area according to the West Kern Water District. In addition the previous UIC permit conditions provided for numerous and complementary protective measures to prevent the contamination of USDWs, whether or not USDWs existed within the project area.

Considerations Under Federal Law

There is a list of Federal laws that may apply to the issuance of permits under the UIC program rules according to 40 CFR Part 144.4. When any of these laws is applicable, its procedures must be followed. The laws that require consideration are: The Wild and Scenic Rivers Act, The National Historic Preservation Act of 1966, The Endangered Species Act, The Coastal Zone Management Act and the Fish and Wildlife Coordination Act. The information regarding the requirements of Part 144.4 pertaining to this application is discussed and presented in **Attachment B**.

Drilling and Testing Results

The first two disposal wells, 25-18G and 35-18G, were drilled and completed in March and April 2002, respectively. Well 25-18G was completed with 8-5/8"/32# slotted casing (200M x 2", 24R, 6"C) from 720′-1,745′ across the Tulare formation interval. Similarly, well 35-18G was completed with 8-5/8"/32# slotted casing (200M x 2", 24R, 6"C) from 650′-1,800′.

Injection started in April 2003 for well 35-18G. The well operated at a high surface wellhead pressure (120-190 psig) and required frequent acid stimulation cleaning treatments to maintain the desired injectivity performance. Well 25-18G also started injection in April 2003 and immediately exhibited similar injectivity problems to well 35-18G. In both cases, a damaged completion was suspected as the cause of the poor injection performance of the wells.

Subsequently in December 2003, offset injection wells 25A-18G and 35A-18G were drilled and completed in the Tulare formation. The two new wells were located in close proximity to the existing injection wells (see **Exhibit B-3**). Both new completions used a ‘foamed in’ slotted liner consisting of 5-1/2”/17# slotted casing (200M x 2”, 24R, 6”C) from 724′-1,415′ for well 25A-18G and from 648′-1,289′ for well 35A-18G. Wastewater injection started in January 2004 for the two new wells. The 25A-18G and 35A-18G well performance has been outstanding with high injectivity occurring at mostly zero surface wellhead pressures.

The construction information for the four disposal wells is presented in **Attachment L**. Due to its apparently damaged completion and poor injection performance, well 25-18G was plugged and abandoned in September 2010 (see **Attachment Q**).

Historical Performance of Class I Wells

The Class I disposal wells have been in operation since April 2003. Wells 25-18G and 35-18G operated primarily in 2003-2004 period. Wells 25A-18G and 35A-18G, drilled to supplement the disposal capability, have operated almost continuously since both wells started injection in January 2004. The cumulative injection by well through December 31, 2010 is:

Well	25-18G	35-18G	25A-18G	35A-18G
Cumulative Injection, gallons (barrels)	12,158,400 (289,486 bbl)	89,657,100 (2,134,694 bbl)	344,811,000 (8,209,785 bbl)	712,878,500 (16,973,297 bbl)
% of Total Injection	1%	8%	30%	61%

Yearly injection performance by well is presented in **Attachment H**.

Nearly all of the injected wastewater (91 percent) has been disposed of in wells 25A-18G and 35A-18G. Well 25A-18G has taken 30 percent of the cumulative injection and well 35A-18G has taken 61 percent of the cumulative injection through December 31, 2010. Both wells are operating as designed and have not shown any signs of deterioration in injectivity performance. The current injection rate has remained fairly constant, averaging 200 gpm.

The quarterly EPA UIC Well Monitoring Reports submitted by EHP under the previous UIC permit included Hall plots for each injection well. The Hall plot is a useful tool for evaluating performance of injection wells. The Hall method is a continuous monitoring method whereby reservoir properties are measured over a period of months and years. The plot is used to identify changes in injection characteristics that may occur over these extended periods of time.

As part of the quarterly operating data submitted to the EPA, EHP will provide a conventional Hall plot for each permitted injection well. However, a modified version of the Hall plot will also submitted such that in the event the surface tubing pressure is zero or less, the calculations will take the integral of the difference between an estimated bottomhole injection pressure and the reservoir boundary pressure with respect to time. The modified Hall plots look like the "conventional" Hall plots and may be used to observe changes in the line slopes as part of monitoring injection characteristics.

The Hall Plots are discussed and compared for each disposal well in **Attachment H**.

Formation Testing Program

The EHP formation testing program will include an annual fall-off test (FOT) to obtain formation pressure, temperature and formation physical characteristics of permeability and skin factor (damage ratio). A comparison and discussion of the historical FOTs is presented in **Attachment I**. The recent FOT surveys show that the Tulare formation pressure has not increased appreciably since injection began in April 2003. The beginning formation pressure is estimated to be 155 psig at 730 feet depth from offsetting well 45SW-18G. The two most recent fall-off tests on well 25A-18G in September 2010 and October 2010 exhibited formation pressures of 160 psig and 155 psig, respectively at the datum depth of 730 feet.

A step rate test (SRT) to assess fracture pressure for the Tulare injection zone was conducted for injection well 35-18G on July 18, 2003. Surface and bottomhole pressures were recorded for a series of increasing injection rates. The SRT interpretation (**Exhibit I-2**) showed that the formation parting pressure was not reached for the maximum injection rate during the test. At the maximum rate, the maximum surface pressure was 248 psig and the corresponding bottomhole pressure was 521 psia (@ 698 feet). The conclusion is that the surface injection pressure will have to be greater than 248 psig before the injection will fracture the formation.

EHP proposes that the Maximum Surface Injection Pressure (MSIP) be set at 80 percent of the formation parting pressure at the corresponding surface pressure conditions. Based on the SRT conducted in 2003, the maximum surface data value without fracturing the formation was 248 psig. At 80 percent, the proposed MSIP is 198 psig.

Monitoring Program and Results

Attachment P outlines the ongoing monitoring program for the injection operations at the disposal site. The monitoring program consists of continuous readings of injection pressure, annular pressure, flow rate, flow volume, as well as quarterly sampling and analysis of the injected wastewater. Annual wireline logging will include temperature and radioactive logs to ensure that no fluid migration is occurring about the shoe of the 8-5/8" diameter casing or around the lower packer. The results of the annual radioactive logs for the past six years have consistently shown no migration around the packer or above the shoe in each of the active injection wells.

Measurements and data will be submitted to EPA on a quarterly basis and maintained at the site for inspection. The injection fluid will be monitored for organic and inorganic constituents and associated physical data as described in **Attachment P**.

Plugging and Abandonment Program and Results

Once an injection well or wells are no longer necessary or not performing as required, the well will be abandoned in accordance with the California Division of Oil Gas and Geothermal Resources (DOGGR) and EPA abandonment procedures. **Attachment Q** provides a general plugging and abandonment program for an injection well. The exact depths of the plugs and abandonment procedures will be determined at the time of the notice of intention to abandon well. The procedure outlined in **Attachment Q** is the official abandonment program approved for well 25-18G. This program was completed in September 2010 for this well.

ATTACHMENT A – AREA OF REVIEW METHODS

Instructions

UIC regulations require that an Area of Review (AOR) be established around a new injection well for the investigation of possible pathways for out-of-zone migration of injection fluids. The determination of the AOR is based on a calculated zone of endangering influence (ZEI) over the life expectancy of the injection well for both the pressure front and the waste front. Regulations require that a minimum AOR for a Class I non-hazardous well is a fixed radius of ¼ mile (1,320 feet) around the injection well but it may be larger as defined by site-specific conditions.

Estimated Area of Review – Warner and Lehr Equations

The AOR in the original UIC application ten years ago was a fixed 0.5 (one-half) mile radius from the Class I wellbores (**Exhibit A-1**). Additional information regarding the methods used in the determination of the Area of Review was provided to the EPA in a letter to Ms. Laura Tom Bose, Groundwater Office of the Environmental Protection Agency Region IX, *Subject: UIC Permit Application Elk Hills Power Plant Permit No. CA200002, EPA Technical Review,* prepared by San Joaquin Energy Consultants, Inc., dated March 7, 2000 (**Exhibit A-2**), and a letter to Mr. George Robin, Groundwater Office of the Environmental Protection Agency Region IX, *Subject: UIC Permit Application Elk Hills Power Plant Permit No. CA200002, Response to CURE comments on draft UIC permit for Elk Hills Power Plant,* prepared by San Joaquin Energy Consultants, Inc., dated October 18, 2000 (Exhibit A-3).

The AOR for this application was evaluated using the volumetric method of Warner and Lehr (EPA document 600/2-77-240, December 1977). This method is a standard, industry accepted method which compares the injection volumes with the porosity and storativity of the injection zone. The methodology assumes that the injected wastewater will uniformly occupy an expanding cylinder away from the injection wells assuming horizontal flow and reasonable estimates of dispersion.

For this application, the waste front radius calculations from the original application (pg. 15 of **Exhibit A-1**) are updated in **Exhibit A-4** taking into account the actual injection history since startup in 2003 and future injection rate predictions. The results of the updated waste front calculations are shown below.

Waste Front Location in Tulare formation - Warner and Lehr Equations (Proposed AOR = 2,640 feet fixed radius)			
550 ft net injection interval	Years	Without Dispersion, feet	With Dispersion, feet
Cumulative Wastewater Injection of 27.6 million barrels as of 12-31-10	8	514	604
History plus Current Rate Forecast	20	780	891
History plus High Rate Forecast	20	944	1067

The calculations are made using equations 3-10 and 3-11 provided by Warner and Lehr in "An Introduction to the Technology of Subsurface Wastewater Injection", December 1977. The waste front calculations use a revised net thickness of 550 feet compared to 750 feet in the previous calculation. The gross Tulare interval is 1,200 feet. This revised net thickness is based on the intervals open and taking water in wells 25A-18G and 35A-18G. Injection intervals for wells 25A-18G and 35A-18G are shown in **Exhibit P-2**.

There are many simplifying assumptions to the Warner and Lehr methodology that limit its ability to predict wastewater travel; however, no other attempts have been made to determine the actual wastewater distribution around the permitting wells, so there is no evidence for comparison with theory. As a result, the Warner and Lehr formulas are relied on for a first order approximation of the location of the waste front. The calculations in **Exhibit A-4** show an area of influence of 891 feet and 1,067 feet after a total of 20 years of injection for the current rate and maximum rate forecasts, respectively. These distances are sufficiently less than the AOR of 2,650 feet to allow for the limitations of the methodology and any additional complications.

The waste front calculations are presented for both a current rate case and high rate case after taking into account the actual wastewater injection volumes through the year 2010. The current rate forecast is determined using a two-year average of the disposal rates for the most recent operational history, years 2009 and 2010 (3,000,000 barrels per year). The high rate forecast case is based on the design capacity of the power plant and it represents the maximum possible daily wastewater volume (628,500 gallons per day).

Completion intervals for the permitting wells include: 698′ to 1795′ MD KB (1097′ open) for 35-18G; 729′ to 1420′ (691′ open) for 25A-18G; and 648′ to 1289′ (641′ open) for 35A-18G. All of these are in excess of the 550′ used above for the net thickness.

These updated waste front location calculations support the previous AOR of 0.5 mile with respect to providing detailed information on wells and other possible pathways for injection fluids. As such, an AOR of 0.5 mile from the location of the existing injection wells is proposed for and used in the remainder of this permit application.

Estimated Area of Review – Pressure Wave Calculation Method

To estimate the possible increase in formation pressure resulting from the injection volumes at specific times and distances from the three injection wells, equation 3-9a was used from the Warner and Lehr reference. This equation assumes that the system has reached steady state from injection, a good assumption for this project because the inputs are analyzed after a long period (20 years) of injection.

The results of the pressure front calculations are presented in **Exhibit A-5** and summarized below. Assuming an AOR of 0.5 miles, the formation pressures are projected to increase less than 10 psi at distance of 2,640 feet from the injection wells. This is a minor increase in pressure which reasonably cannot be expected to cause any out-of-zone migration.

Pressure Front Calculations after 20 years of injection		
550 ft net injection interval	Pressure Increase in Tulare Zone	
Distance from injection wells, feet	History plus Current Rate Forecast	History plus High Rate Forecast
10	6.5 psi	11.2 psi
100	5.2 psi	8.9 psi
250	4.6 psi	7.9 psi
500	4.2 psi	7.2 psi
750	4.0 psi	6.8 psi
1000	3.8 psi	6.5 psi
2000	3.4 psi	5.8 psi
2640	3.2 psi	5.5 psi

ATTACHMENT B – MAPS OF WELL/AREA AND AREA OF REVIEW

Instructions

This section presents information on the physical setting and manmade features at and surrounding the project site to ensure that the project poses no threat to drinking water supplies. The project site and the area of review must be shown on a topographic map that extends one mile beyond the project area. Intake and discharge structures, and hazardous waste treatment, storage, or disposal facilities within one mile of the project area must also be mapped. For the permitting Class I UIC wells, the location and identification of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, mines, quarries, residences and roads, faults, and other pertinent surface features must also be mapped. Finally, the considerations under Federal law in 40 CFR Part 144.4 that may apply to the issuance of these UIC permits are addressed in this Attachment.

Physical Setting and Surface Water Features

The project UIC injection wells are located on the western side of the San Joaquin Valley, about 4.5 miles north of the town of Taft, in Section 18, Township 31 South, Range 24 East, Mount Diablo Base Meridian (**Exhibit B-1)**. The area consists of gently sloping northwest-southeast trending hills and valleys, ranging in elevations from lows of about 500 feet above mean sea level to highs of about 1500 feet above mean sea level.

The project area is located on the north edge of the Buena Vista Valley, with the Elk Hills directly to the north and the Buena Vista Hills directly to the south. The project site is at an elevation of approximately 600 feet above mean sea level (**Exhibit B-2**). The topography at the project site slopes gently to the south, and surface drainage patterns trend generally from the northwest to southeast into Buena Vista Valley. No bodies of water or springs have been mapped within one mile of the project area.

The average annual precipitation (period of record: 7/1/1948 to 12/31/2010) for the nearby city of Taft is 5.53 inches, with most of the rainfall occurring from January through March (Western Regional Climate Center, DRI, Nevada System of Higher Education, June 2011).

No faults have been mapped within one mile of the project area (Milliken, 1992; California Division of Mines and Geology, 1976).

Wells within the Area of Review

Seventeen wells are mapped within the area of review by the DOGGR Online Mapping System (**Exhibit B-3**). Two plugged and abandoned oil production wells (1-18G and 2-18G, designated with “Dry Hole” symbols) are located east of the project UIC wells. One plugged and abandoned water source well (45WS-18G, designated with a “Dry Hole” symbol) is located north of the project UIC wells, and two plugged and abandoned water source wells (84W-13B and 284WS-13B, designated with "Dry Hole" symbols) are located west of the project UIC wells. Two plugged and abandoned water disposal wells (54WD-18G and 64WD-18G, designated with "Dry Hole" symbols) are located east of the project UIC wells. A third plugged and abandoned water disposal well (25-18G, designated with a "Plugged" symbol), formerly a project UIC well, is located directly adjacent to the west of the current project UIC wells. Nine active water disposal wells (27WD-18G, 37WD-18G, 54XWD-18G, 56WD-18G, 57WD-18G, 64XWD-18G, 67WD-18G, 85-13B, and 87WD-13B, designated with "Active Injector" symbols) are located west, south, and east of the project UIC wells.

Other Manmade Features

Documentation of the Elk Hills Pipeline Project Supply Water and Wastewater Systems is provided in **Attachment K**.

The Elk Hills oil field surface facilities including piping, wastewater pumps and tanks, and dehydration trains are shown in **Exhibit B-4** (San Joaquin Energy Consultants). No mining or quarrying has been mapped within one mile of the project area (**Exhibit B-2**).

No hazardous waste treatment, storage, or disposal facilities are located within one mile of the project site (**Exhibit B-2**).

Considerations under Federal Law

The following list of Federal laws is considered for this application pursuant to 40 CFR Part 144.4.

(a) The Wild and Scenic Rivers Act [16 U.S.C. 1273]
The conditions for this UIC permit application do not require consideration of the regulations associated with The Wild and Scenic Rivers Act.

(b) The National Historic Preservation Act of 1966 [16 U.S.C. 470]
Pursuant to requirements of 36 CFR Part 800 regarding the National Historic Preservation Act (NHPA), and prior to issuance of the original UIC permit in February 2001, the EPA consulted with the State of California's Office of Historic Preservation (OHP) regarding potential impact to historic properties during the development of Elk Hills Power Plant (EHPP).

EPA reviewed and evaluated cultural resource field surveys and extensive literature reviews of the area of the EHPP conducted by the California Energy Commission and Foster Wheeler Environmental Corporation. In a letter to the OHP dated December 4, 2000, EPA summarized the results of the investigations and concluded that "no further actions are required for EPA to satisfy its obligations under the NHPA with regard to the issuance of the UIC permit" (**Exhibit B-5**).

In its issuance of the original UIC permit, the EPA stated that "EPA has satisfied its responsibilities under the NHPA at this time and may issue the final UIC permit" (Response No. 16, "Response To Comments", Underground Injection Control Program, Class I Nonhazardous Waste Injection Draft Permit No. CA2000002, February 16, 2001 – **Exhibit B-6**). Since this UIC permit re-application proposes neither surface nor subsurface development, no new potential impact to historic property exists and, we believe that no further consultation between the EPA and OHP is needed to meet the requirements of 36 CFR Part 800 for Protection of Historic Properties.

(c) The Endangered Species Act [16 U.S.C. 1531]

Pursuant to requirements of 50 CFR Part 402 regarding the Endangered Species Act (ESA), and prior to issuance of the original UIC permit in February 2001, the EPA consulted with the United States Bureau of Land Management (BLM; designated as lead agency) and the Department of the Interior Fish and Wildlife Service (FWS) regarding the development and maintenance of the EHPP and the potential impact it may have with regard to biological resources in the area addressed by the ESA.

As part of the permitting process underway in 2000, EHP developed, and has subsequently followed, protocols for surveying and reporting biological resources at the power plant. These protocols are given in the "Biological Resources Mitigation and Implementation Monitoring Plan" (drafted October 2, 2000; finalized May 15, 2001 – **Exhibit B-7).**

The FWS issued a Biological Opinion on January 17, 2001 regarding the EHPP (United States Department of the Interior, Fish and Wildlife Service, Memorandum, "Formal Section 7 Consultation on the Elk Hills Power Project, Kern County, California" – **Exhibit B-8**).

When issuing the original UIC permit, EPA stated that it had "reviewed the biological opinion and determined that issuance of the final UIC permit is consistent with the requirements of the Endangered Species Act" (see Response No. 15 in **Exhibit B-6)**.

In consideration of the ongoing monitoring and reporting of biological resources for the EHPP with regard to the Endangered Species Act, we believe that no further consultation between the EPA and FWS and BLM is needed to meet the requirements of 40 CFR Part 144.4 with regard to the ESA.

(d) The Coastal Zone Management Act [16 U.S.C. 1451]

The conditions for this UIC permit application do not require consideration of the regulations associated with Coastal Zone Management Act.

(e) The Fish and Wildlife Coordination Act [16 U.S.C. 661]

The conditions for this UIC permit application do not require consideration of the regulations associated with the Fish and Wildlife Coordination Act.

ATTACHMENT C – CORRECTIVE ACTION PLAN AND WELL DATA

Instructions

This section presents a tabulation of well data (well name, API number, well type, date drilled, location, total and effective depths, and current status), followed by records of completion or plugging and abandonment from the State of California, Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) for all wells within the Area of Review that penetrate the target injection zone.

If any well within the Area of Review penetrates the injection zone and has not been properly sealed, completed, or plugged to prevent migration of injectate into the wellbore, a Corrective Action Plan is required.

Closest Wells that Penetrate Injection Zone

As discussed in **Attachment B**, there are 17 wells within the 0.5-mile AOR that have penetrated the target injection zone. These wells are listed in **Exhibit C-1**. The well histories and operations data for each well, available from the DOGGR public records, are submitted in **Exhibit C-2**. A summary of each well is presented below.

Well 45W-18G

Well 45WS-18G was a water source well drilled in November 1992 to a total depth of 2000 feet, and completed with perforations from 1997 feet to 984 feet. The top of the Tulare Clay was logged at a depth of 480 feet, and the base of the Tulare Clay was logged at 565 feet.

Abandonment and surface plugging of 45WS-18G was completed on October 18, 2005, and site inspection and approval by the DOGGR was conducted on January 18, 2006.

Well 1-18G

Well 1-18G was an oil production well drilled in 1934 to an estimated depth of 250 feet, which did not penetrate the injection zone, and was not completed. The well was plugged and abandoned in May 1934.

Well 54WD-18G

Well 54WD-18G was a water source well drilled in November 2001 to a total depth of 1100 feet, and completed with perforations from 1087 feet to 541 feet. The top of the Tulare Clay was logged at a depth of 446 feet, and the base of the Tulare Clay was logged at 535 feet.

Abandonment and surface plugging of 54WD-18G was completed on December 22 2006, and approval by the DOGGR was given on March 3, 2009.

Well 2-18G

Well 2-18G was an oil production well drilled prior to May 1934 to a total depth of 1860 feet. Details of perforations are not available in the well record.

Abandonment and surface plugging of 2-18G was completed on January 4, 2002, and approval by the DOGGR was given on March 12, 2002.

Well 64XWD-18G

Well 64XWD-18G is an active water disposal well drilled in January 2007 to a total depth of 1360 feet, and completed with perforations from 1357 feet to 543 feet. The top of the Tulare Clay was logged at a depth of 433 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 543 feet were reviewed and approved by the DOGGR on October 12, 2007.

Well 64WD-18G

Well 64WD-18G was a water disposal well drilled in November 2001 to a total depth of 1350 feet, and completed with perforations from 1184 feet to 474 feet. The top of the Tulare Clay was logged at a depth of 434 feet, and the base of the Tulare Clay was logged at 511 feet.

Abandonment and surface plugging of 64WD-18G was completed on December 14 2006, and site inspection and approval by the DOGGR was conducted on December 20, 2006.

Well 54XWD-18G

Well 54XWD-18G is an active water disposal well drilled in January 2007 to a total depth of 1100 feet, and completed with perforations from 996 feet to 506 feet. The top of the Tulare Clay was logged at a depth of 433 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 506 feet were reviewed and approved by the DOGGR on November 2, 2007.

Well 56WD-18G

Well 56WD-18G is an active water disposal well drilled in January 2007 to a total depth of 1702 feet, and completed with perforations from 1698 feet to 782 feet. The top of the Tulare Clay was logged at a depth of 632 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 782 feet were reviewed and approved by the DOGGR on October 12, 2007.

Well 57WD-18G

Well 57WD-18G is an active water disposal well drilled in April 2002 to a total depth of 2600 feet, and completed with perforations from 1695 feet to 865 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 865 feet were reviewed and approved by the DOGGR on July 15, 2002.

Well 37WD-18G

Well 37WD-18G is an active water disposal well drilled in September 2002 to a total depth of 1800 feet, and completed with perforations from 1799 feet to 825 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 825 feet were reviewed and approved by the DOGGR on February 11, 2003.

Well 27WD-18G

Well 27WD-18G is an active water disposal well drilled in September 2002 to a total depth of 1800 feet, and completed with perforations from 1799 feet to 803 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 803 feet were reviewed and approved by the DOGGR on January 13, 2003.

Well 87WD-18G

Well 87WD-18G is an active water disposal well drilled in November 2002 to a total depth of 1530 feet, and completed with perforations from 1312 feet to 594 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 594 feet were reviewed and approved by the DOGGR on February 25, 2003.

Well 85WD-18G

Well 85WD-18G is an active water disposal well drilled in May 2003 to a total depth of 1450 feet, and completed with perforations from 1437.87 feet to 746 feet. The top of the Tulare Clay was logged at a depth of 733 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 746 feet were reviewed and approved by the DOGGR on August 25, 2003.

Well 84W-13B

Well 84W-13B was a water source well drilled in October 1979 to a total depth of 1950 feet, and completed with perforations from 1900 feet to 1056 feet. The top of the Tulare Clay was logged at a depth of 542 feet, and the base of the Tulare Clay was logged at 618 feet.

Abandonment and surface plugging of 84W-18G was completed on August 23, 2005, and site inspection and approval by the DOGGR was conducted on September 9, 2005.

Well 284WS-13B

Well 284WS-13B was a water source well drilled in October 1979 to a total depth of 1950 feet, and completed with perforations from 1900 feet to 1056 feet. The top of the Tulare Clay was logged at a depth of 542 feet, and the base of the Tulare Clay was logged at 618 feet.

Abandonment and surface plugging of 284WS-18G was completed on December 6, 2001, and site inspection and approval by the DOGGR was conducted on May 28, 2002.

Well 67WD-18G

Well 67WD-18G is an active water disposal well drilled in April 2002 to a total depth of 1768 feet, and completed with perforations from 1763 feet to 905 feet.

Injection survey operations to demonstrate that the injection fluid is confined to strata below 904 feet were reviewed and approved by the DOGGR on August 17, 2004.

Well 25-18G

Well 25-18G was the initial UIC disposal well drilled in March 2002 to a total depth of 1760 feet and completed with perforations from 1745 feet to 720 feet. The top of the Tulare Clay was penetrated at a depth of approximately 475 feet, with the base of the Tulare Clay at a depth of approximately 700 feet. The wireline logs run in this well are included in the supporting documentation on CD-Rom.

Abandonment and surface plugging of 25-18G was completed on September 22, 2010 and site inspection and approval by the DOGGR was conducted on September 22, 2010.

Summary

All wells within the Area of Review have been approved by the DOGGR as being properly sealed, completed, or abandoned, demonstrating that these wellbores could not act as conduits for injection fluid. Therefore, no corrective action is required for wells located within the Area of Review.

ATTACHMENT D – MAPS AND CROSS SECTIONS OF USDWS

Instructions

This section identifies all underground sources of drinking water (USDW) within the Area of Review. For USDWs in the Area of Review, maps and cross sections indicating the vertical and lateral limits of each USDW and its position relative to the injection formation and the direction of water movement, where known, are required.

USDWs

There are no Underground Sources of Drinking Water (USDW) within the Area of Review (communication from Jerry W. Pearson, General Manager, West Kern Water District, received 31 August 2010, **Exhibit D-1**).

The EPA determined that, with regard to the Tulare Formation in the Area of Review, "the Tulare formation is an exempted aquifer and is therefore not protected as an USDW" (EPA Region IX, Underground Injection Control Program, Class I Nonhazardous Waste Injection Draft Permit No. CA20002, Response to Comments, February 16, 2001, **Exhibit B-6**).

ATTACHMENT E – NAME AND DEPTH OF USDWS (CLASS II)

Class II wells only – not applicable to this application

ATTACHMENT F – MAPS & CROSS SECTIONS OF GEOLOGIC STRUCTURE OF AREA

Instructions

This section describes the regional geologic setting of the project site with generalized maps and cross sections depicting the regional geology, and presents the geologic structure of the local area, including the lithology of the injection and confining intervals, with maps and cross sections of the local geology.

Regional Geology

Regional geology of the project site was originally presented in the 1999 project UIC injection well permit application (*"Information Needs for Class V Injection Wells, Elk Hills Power Plant, Elk Hills Power, LLC, Elk Hills Oil Field, Kern County, California",* Section 3, September 20, 1999 (**Exhibit A-1**). A brief summary of that information follows.

The project area is in the southwest San Joaquin Basin, in an area of moderately folded northwest-southeast trending anticlines and synclines (**Exhibits F-1 and F-2**). The regional stratigraphy of the project area consists of a thick section of sedimentary rocks ranging in age from Cretaceous to Recent (**Exhibit F-3**). Miocene marine sediments are overlain by a Pliocene sequence that transitions to near-shore and brackish water environments. The Pleistocene Tulare Formation consists of non-marine, primarily alluvial and fluvial sediments.

Regional seismically active faults include the San Andreas fault, which lies about 12 miles west of the project area in the Temblor Range, the White Wolf fault approximately 25 miles southeast of the project area, and the Pond-Poso fault about 22 miles northeast of the project area.

The California Uniform Building Code (UBC, Section 2312) defines the area where the project site is located as a seismic Zone 4 area, which is the highest potential on a scale from 0 to 4 (Foster Wheeler Environmental Associates, 1999.) This category requires structural design considerations to protect buildings and other structures from earthquake damage.

Local Geology

Local geology at the project site was originally presented in the 1999 project UIC injection well permit application (**Exhibit A-1**). A brief summary of that information follows.

The project site sits on Quaternary fan deposits in the northwest-southeast trending syncline that forms the Buena Vista Valley, between the gently folded northwest-southeast trending anticline comprising Quaternary Plio-Pleistocene non-marine sedimentary rocks of the Elk Hills directly north and the Buena Vista Hills directly south.

Interbedded Tulare gravels and the Tulare clay, members of the Tulare Formation, outcrop in the Elk Hills, dipping from 27 degrees to 14 degrees to the south along the southern edge of the anticline, and decreasing in dip to 9 degrees to 4 degrees to the south near the crest of the Hills (**Exhibits F-4, F-5,** and **F-6**).

No faults have been mapped within the Area of Review. Two Potentially Active Faults, as defined by the State of California Special Studies Zones and evidenced by displacement caused by creep or possible creep, have been identified approximately located about 5 miles south of the project area, near the town of Taft (California Division of Mines and Geology, 1976).

Tulare Zone Lithology

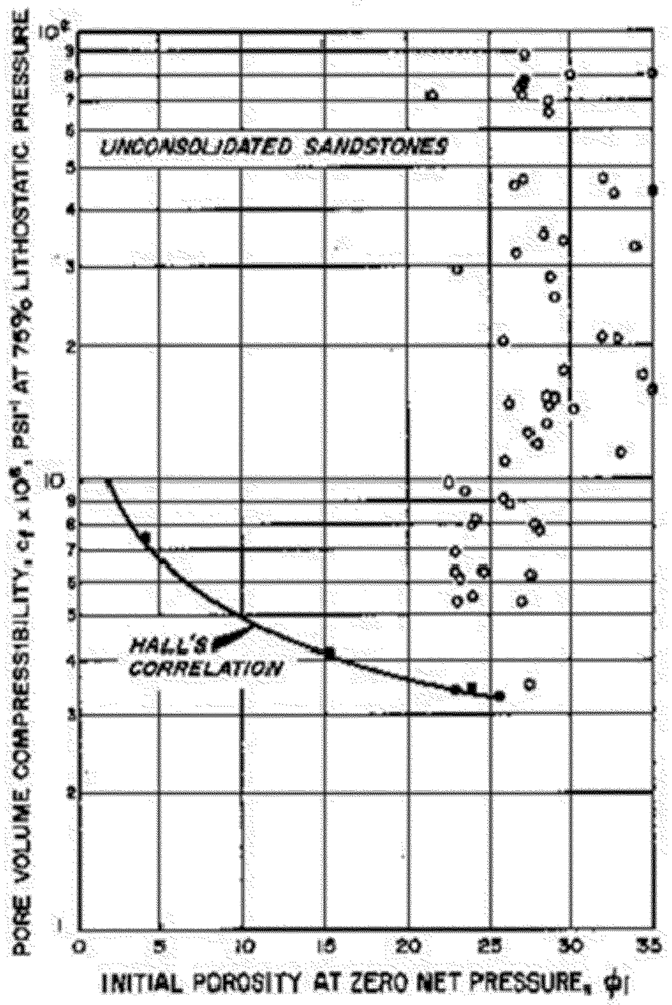
Core samples cut from whole cores taken in the well 46WD-7G were used to characterize the lithology of the Tulare formation. Well 46WD-7G is located approximately 4,400 feet north of the project site (se **Exhibit F-10**). Core from the Tulare and the confining shales in this well provide the nearest available core data that are on the same structure and stratigraphically equivalent to the Tulare zone in the permitting wells (even though outside of the AOR). The core analyses are found in **Exhibit A-1**, attachment 9 along with a well log that shows the depths of the cored intervals.

The mean air permeability for 66 core samples in the Upper and Lower Tulare is 2,180 millidarcies (md). In comparison, an average permeability of 2,050 md is reported for the Tulare zone in the neighboring Elk Hills oil field by the California Division of Oil, Gas, and Geothermal Resources (DOGGR). The falloff test data, presented in **Attachment I** for the permitting wells, yield effective water permeability in the range of 1,695 to 3,040 md. The average porosity of core samples from 46WD-7G is 34 percent compared with the average porosity of 33 percent reported by DOGGR. Based on these favorable comparisons, the Tulare zone core samples from well 46WD-7G are considered to be representative of the Tulare zone lithology in the permitting wells and AOR.

Reservoir Compressibility

The pore volume compressibility value for the Tulare injection interval was estimated using Hall's Correlation for consolidated sandstones even though the Tulare zone is more properly characterized as unconsolidated sandstone due to its shallow depth and high permeability. For unconsolidated reservoirs, correlations can be expected to give only order-of-magnitude estimates. The best result is obtained when formation compressibility is measured in the laboratory for the reservoir being studied.

If we were to consider pore volume compressibility data for unconsolidated sandstones as evaluated by Newman, 1973 (see figure below), we would find that there is no correlation comparable to Hall and, if there is a correlation for unconsolidated samples, the trend may be opposite the trend for consolidated samples. For this application, a pore volume compressibility value of 3.4×10^{-6} psi $^{-1}$ was selected as the lowest value of compressibility in the Newman cross-plot for the Hall's Correlation. The pore volume compressibility values for unconsolidated samples with porosities in the range of 30 – 35 percent were all significantly higher and scattered.



Pore-volume compressibility at 75-percent lithostatic pressure vs initial sample porosity for unconsolidated sandstones. After Newman.

Reservoir compressibility is used in the pressure front calculations in **Exhibit A-5** to predict the formation pressure at any distance from the injection well. In these calculations, the predicted pressure distribution away from the injection well decreases with increasing reservoir compressibility. For this reason, to err on the side of a greater pressure increase, the value of 3.4 x 10^{-6} psi $^{-1}$ was assumed for the Tulare reservoir compressibility. The pressure front was also evaluated for a reservoir compressibility of 30 x 10^{-6} psi $^{-1}$ (see **Exhibit A-5**).

Lithology of the Confining Interval

The lithology of the confining interval was originally detailed in the 1999 project UIC injection well permit application (**Exhibit A-1**). A brief summary of that information follows.

The Tulare clay, a non-marine member of the Pleistocene upper Tulare Formation, is the upper confining zone for these project UIC wells. The clay consists primarily of buff silty clay with minor thin interbeds of grey sandy gravel. The Tulare clay is approximately 80 feet thick in the area of the project UIC wells.

The local structure of the Tulare clay confining zone consists of a northwest-southeast trending syncline south of the Elk Hills anticline, and appears to be areally extensive, with good continuity both laterally and vertically (**Exhibits F-7, F-8,** and **F-9**).

The top Tulare clay interval was encountered at a depth of 600 feet KB in UIC well 35-18G, and the base Tulare clay was encountered at a depth of 704 feet KB. In UIC well 25-18G, the top Tulare clay interval was encountered at a depth of 629 feet KB and the base Tulare clay was encountered at a depth of 724 feet KB.

Permeability of the Tulare clay confining interval was estimated to be 44 md based on core samples in clays and siltstones within the upper Tulare Formation from well 46WD-7G. The quantitative analyses are presented in Attachment 9 of **Exhibit A-1**.

Porosity of the Tulare clay confining interval was estimated to be 32 percent based on conventional core analyses of core samples in clays and siltstones within the upper Tulare Formation from well 46WD-7G. The porosity estimate was calculated using the arithmetic mean of porosities from six core samples. The quantitative analyses are presented in Attachment 9 of **Exhibit A-1**.

The compressibility of the Tulare clay is estimated to be 3.4×10^{-6} psi^{-1} as discussed previously.

Lithology of the Injection Interval

The lithology of the injection interval was originally detailed in the 1999 project UIC injection well permit application (**Exhibit A-1**). A brief summary of that information follows.

The injection interval comprises the sands and gravels of the Pleistocene upper Tulare Formation. The upper Tulare sands are generally very clean and well sorted and are commonly interbedded with gravels. The upper Tulare Formation is an alluvial and/or fluvial deposit.

The local structure of the injection interval comprises a northwest-southeast trending syncline south of the Elk Hills anticline. The structure at the top of the injection interval (the base of the Tulare clay) is shown in **Exhibit F-7**, and the structure at the base of injection interval (the top of the Amnicola clay) is shown in **Exhibit F-10**. The average gross thickness of the injection interval is 1,200 feet; the approximate net sand thickness of the injection interval is 750 feet (**Exhibit F-11**). The injection interval appears to have good lateral and vertical continuity (**Exhibits F-8, F-9,** and **F-11**). No faults appear to occur in the injection zone within the Area of Review.

Permeability of the injection interval: estimated to be 3,757 md based on the geometric mean of 37 cores samples from the sands within the upper Tulare Formation from well 46WD-7G.

Porosity of the injection interval: estimated to be 34 percent based on the arithmetic mean of porosities from sands from the upper Tulare Formation in well 46WD-7G.

Reservoir pressure of the injection interval: 276 psia based on well 45WS-18G; top of perforations at a depth of 974 feet.

Storage coefficient of the injection interval (equation 2-6, Warner and Lehr): (0.34)*(0.433 psi/ft)*(550ft)*[(3x10^{-6})+(3.4x10^{-6})] = 0.000518

Hydraulic conductivity of the injection interval: 3.757 darcy * 2.725 ft/day/darcy (conversion factor) = 10.24 ft/d

Transmissivity of the injection interval: 10.24 ft/d * 550 ft = 5,632 ft^2/d = 42,127 gal/d/ft

Estimated formation fracture pressure of the injection interval: 583 psi (0.8 psi/ft at top of 25A-18G slots at a depth of 729 ft, without friction loss); 518 psi (0.8 psi/ft at top of 35A-18G slots at a depth of 648 ft, without friction loss); based on DOGGR fracture gradient of 0.8 psi/ft for the 18G area.

Discussions regarding the characteristics of the injection interval (the Tulare Formation) and overlying confining layer, and the exemption of the Tulare aquifer from USDW status were detailed in a letter to Ms. Laura Tom Bose, Groundwater Office of the Environmental Protection Agency Region IX (**Exhibit A-2**), a letter to Mr. George Robin, Groundwater Office of the Environmental Protection Agency Region IX, (**Exhibit A-3**), and the EPA Region IX's February 16, 2001 "*Response To Comments, Underground Injection Control Program, Class I Nonhazardous Waste Injection Draft Permit No. CA200002*" (**Exhibit B-6**).

ATTACHMENT G – GEOLOGICAL DATA ON INJECTION AND CONFINING ZONES

Class II wells only – not applicable to this application

ATTACHMENT H – OPERATING DATA

Instructions

For Class I wells the operating data to be submitted for each injection wells (including all those to be covered by the area permits) are as follows:

1) Average and maximum daily rate and volume of the fluids to be injected;

2) Average and maximum injection pressure;

3) Nature of annulus fluid; and

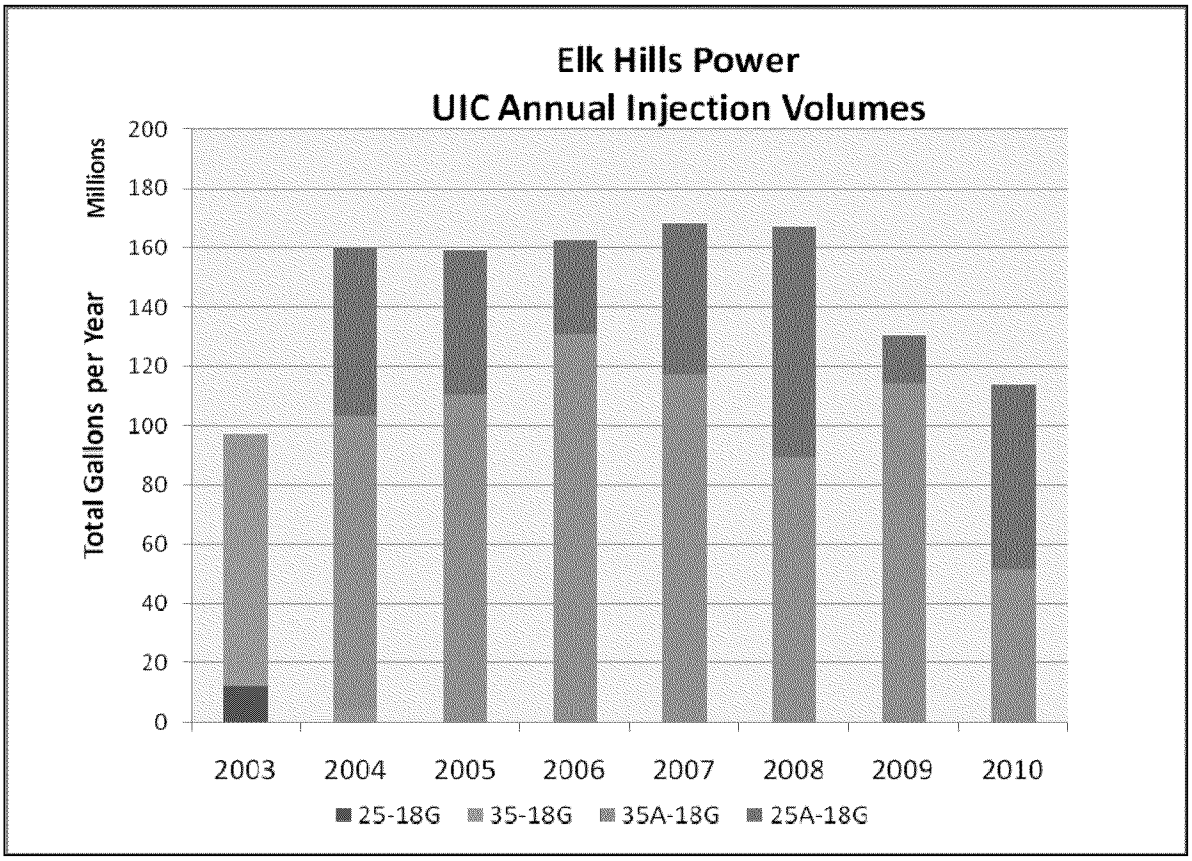
4) Source and analysis of the chemical, physical, radiological and biological characteristics, including density and corrosiveness, of injection fluids.

Historical Operating Data

As discussed previously, the EHP site has been generating and disposing of wastewater since April 2003 under EPA UIC Permit No. CA200002. The operating data for the four injection wells has been reported to the EPA on a quarterly schedule per the permit requirements. The yearly injection volumes, as reported to the EPA, by injection well are tabulated below.

Historical Injection Volumes by Year, Gallons						
YEAR	25-18G	35-18G	35A-18G	25A-18G	TOTAL	CUMULATIVE
2003	12,152,449	85,446,383	0	0	97,598,832	97,598,832
2004	5,964	4,157,583	99,331,600	56,308,834	159,803,980	257,402,812
2005	0	0	110,230,958	48,883,406	159,114,365	416,517,177
2006	0	0	130,986,104	31,943,499	162,929,603	579,446,780
2007	0	129	117,137,166	51,316,942	168,454,237	747,901,017
2008	0	84	89,435,410	77,715,517	167,151,011	915,052,028
2009	1	1,134	114,386,538	16,282,812	130,670,485	1,045,722,513
2010	0	51,828	51,370,704	62,359,962	113,782,494	1,159,505,007
Total	12,158,414	89,657,141	712,878,481	344,810,971	1,159,505,007	
	1%	8%	61%	30%	100%	

The cumulative injection volume is 1,159,505,000 gallons (27,607,000 barrels) through December 31, 2010. Over 90 percent of this volume is disposed of in two wells, 25A-18G and 35A-18G.



The disposal volumes in terms of barrels are:

Historical Injection Volumes by Year, Barrels						
YEAR	25-18G	35-18G	35A-18G	25A-18G	TOTAL	CUMULATIVE
2003	289,344	2,034,438	-	-	2,323,782	2,323,782
2004	142	98,990	2,365,038	1,340,687	3,804,857	6,128,638
2005	-	-	2,624,547	1,163,891	3,788,437	9,917,076
2006	-	-	3,118,717	760,559	3,879,276	13,796,352
2007	-	3	2,788,980	1,221,832	4,010,815	17,807,167
2008	-	2	2,129,415	1,850,369	3,979,786	21,786,953
2009	0.03	27	2,723,489	387,686	3,111,202	24,898,155
2010	-	1,234	1,223,112	1,484,761	2,709,107	27,607,262
Total	289,486	2,134,694	16,973,297	8,209,785	27,607,262	

The specific operating data for all four injection wells during the last six months of 2010 are presented in the following tables. These data are taken from the 2010 3rd and 4th Quarter Underground Injection Well Performance Monitoring Reports submitted to the EPA under Permit No. CA200002.

Well	Average Injection Rate (gpm)					
	Jul 2010	Aug 2010	Sep 2010	Oct 2010	Nov 2010	Dec 2010
25-18G	0	0	0	0	0	0
25A-18G	92	95	164	271	172	174
35-18G	0	0	1	0	0	0
35A-18G	204	179	62	2	0	0
Total	**296**	**274**	**227**	**273**	**172**	**174**

Well	Maximum Injection Rate (gpm)					
	Jul 2010	Aug 2010	Sep 2010	Oct 2010	Nov 2010	Dec 2010
25-18G	0	0	0	0	0	0
25A-18G	127	138	251	337	259	249
35-18G	0	0	35	0	0	0
35A-18G	218	238	187	49	0	0

Well	Average Injection Pressure (psig)					
	Jul 2010	Aug 2010	Sep 2010	Oct 2010	Nov 2010	Dec 2010
25-18G	15	14	0	0	0	0
25A-18G	48	35	2	4	2	14
35-18G	0	2	10	15	6	17
35A-18G	50	32	4	6	0	0

Well	Maximum Injection Pressure (psig)					
	Jul 2010	Aug 2010	Sep 2010	Oct 2010	Nov 2010	Dec 2010
25-18G	17	17	0	0	0	0
25A-18G	53	91	38	21	14	41
35-18G	0	23	52	33	24	44
35A-18G	54	68	53	102	1	0

These actual operating data are representative of the operating conditions expected to be encountered for the three Class I disposal wells in this permit application. It is anticipated that approximately 200 – 300 gpm of wastewater (average month) will be generated at the EHP site for injection under normal operating conditions. The injection wells will be operated so as not initiate or propagate fractures in the formation. The maximum injection surface pressure is discussed under **Attachment I**.

The recent injectate analyses for chemical and physical parameters are available in the 2010 4th Quarter Underground Injection Well Performance Monitoring Report dated January 4, 2011 (**Exhibit H-1**).

The specific nature of the annulus fluid in each permitting well is unknown other than what is reported in the well histories under **Attachment C**. In the case of wells 25A-18G and 35A-18G, the annulus was filled with a fluid described as 'packer fluid' (35 barrels in 25A-18G and 30 barrels in 35A-18G). There is no record of any fluid being placed in the annulus of well 35-18G.

Hall Plots

Injection well operations will be monitored through the use of Hall plots in the quarterly UIC Well Monitoring Reports. The Hall plot is a useful tool for evaluating performance of injection wells. The Hall method is a steady-state analysis method, whereas falloff tests and injection tests are transient methods. Transient pressure analysis such as the annual pressure falloff test determines the reservoir properties at a given point in time. The Hall Plot is a continuous monitoring method whereby reservoir properties are measured over a period of months and years. The Hall plot, therefore, can help identify changes in injection characteristics that may occur over extended periods of time. For example, if an injection well is stimulated, the slope of the line on the Hall Plot decreases with time, and if the well is damaged, the slope increases with time.

The typical industry application of the Hall method is a graphical form of Cumulative Surface Pressure-Days (psig-days) versus Cumulative Injection Volume (barrels). These conventional plots are shown in **Exhibit H-2** for the three permitting wells. However, for this conventional application to work there must be a constant fluid head and surface injection pressure greater than zero. In addition, the boundary reservoir pressure must be close to the weight of a full fluid column in order for the Hall approximation to Darcy's law to be valid.

There is a significant portion of the disposal injection that takes place at zero tubing pressures (wells 25A-18G and 35A-18G – **Exhibit H-3**). As a result, the traditional form of the Hall plot is not suitable; rather, a better procedure is one that takes the integral of the difference between bottomhole injection pressure (Pwf) and reservoir boundary pressure (Pe) with respect to time. Integrating the pressure data with the Hall integral,

$$\{Pwf - Pe\}\, dt,$$

will give the desired slope and have a smoothing effect on the data (Buell, Kazemi and Puettmann).

Static reservoir boundary pressures are measured annually as part of the UIC falloff testing program (see detailed discussion in **Attachment I**). The results show that the Pe pressure has been relatively constant over the past five years at about 163 psig when corrected to a depth of 730 feet (a depth roughly equivalent to the top of the perforated liners in the injection wells).

Bottomhole pressure Pwf, necessary to the integral {Pwf – Pe}dt, is estimated by correcting the recorded surface wellhead pressure for hydrostatic head and friction loss (considered negligible). In the case when surface injection pressure is zero, it is necessary to make a couple of additional simplifying assumptions for this analysis. If the surface pressure is zero and the injection fluid rate is greater than a selected minimum rate (5 gallons per minute), it is assumed that the fluid level is near the surface and therefore Pwf is approximately equivalent to the weight of the fluid column (i.e. 0.433 psi/ft times datum depth). However, if the injection rate is zero or the rate is less than the minimum rate (5 gpm), Pwf is assumed to be equivalent to Pe, reservoir boundary pressure.

The modified Hall plots with the new integral of {Pwf minus Pe}dt are shown for wells 25A-18G and 35A-18G in **Exhibit H-4**. The modified Hall plots now look like the conventional Hall plot and may be used to observe changes in the line slopes as part of monitoring injection characteristics. The spreadsheets for the Hall Plot calculations are given in **Exhibit H-5.**

ATTACHMENT I – FORMATION TESTING PROGRAM

Instructions

The formation testing program for Class I wells is designed to obtain data on fluid pressure, temperature, and fracture pressure of the injection zone. The program also collects data on the physical, chemical, and radiological characteristics of the injection matrix and physical and chemical characteristics of the formation fluids.

Initial Formation Pressure

The initial Tulare zone pressure at the beginning of the disposal project is determined from two sources. The initial reservoir pressure reported in the original 1999 EHP UIC application was 261 psi at 974 feet (top of perforations) in well 45WS-18G. This pressure was based on a measured static water level at 368 feet measured depth (242 feet above sea level, KB = 610 feet) taken September 1, 1994. The calculation is:

$$(974 - 368) \text{ ft} \times 0.43 \text{ psi/ft} = 261 \text{ psig}$$

$$261 \text{ psig} + 15 \text{ psi} = 276 \text{ psia}$$

Well 45WS-18G is located adjacent to the three permitting wells in this application (see **Exhibit B-3**). As a result, the pressure, 276 psia, is a good estimate of the beginning pressure for the Tulare zone prior to the initiation of water disposal in 2003.

The initial pressure also can be estimated for the first disposal well, 25-18G, drilled and completed in March 2002. Using the induction-density-neutron log run in well 25-18G (See Supporting Documentation on **CD-Rom**), the base of the air-filled sands is picked at 364 feet measured depth (249 feet above sea level). This is determined from the density-neutron cross-over (shaded) that occurs in the far right track of the well log. Density-neutron cross-over is a good indicator of gas (air) in the formation. The top of the static water level is assumed to be located approximately at the base of the air-filled sands. In this case, the water level in 25-18G in March 2002 is comparable to the water level for 45WS-18G in September 1999. For purposes of this application, the beginning formation pressure will be 276 psia at 974 feet (364 feet below sea level).

Formation Fall-off Tests

The EHP formation testing program involves an annual falloff test (FOT) to obtain current injection formation pressure and transmissibility data. The results of the FOT, which include fluid pressure, temperature, permeability and static pressure for the formation, will be reported to the EPA. The procedures to be followed are presented in the Elk Hills Power Pressure Fall-Off and Mechanical Integrity Test Procedure (**Exhibit I-1**). The procedure also includes a radioactive tracer survey (RTS) to demonstrate that the injectate is confined to the permitted injection zone.

The static formation pressures determined from the FOTs are compared to the beginning formation pressure to identify changes in the formation pressure level that could be an indication of fill-up or breaching of the Tulare injection zone.

A summary of the static formation pressures since 2003 is presented in the table below. These pressures are measured by the annual FOT conducted by EHP on one of two wells, 25A-18G or 35A-18G.

Tulare Injection Zone Pressure History							
Falloff Test Date	Well	KB feet	Static Formation Pressure psia	Survey Depth feet	Formation Pressure at 730 ft MD Datum psia	Formation Pressure at 730 ft MD Datum psig	Comments
9-1-1999	45WS-18G	610	276	974	170	155	Est. beginning pressure
7-18-2003	35-18G	604	162	698	176	161	
5-4-2005	35A-18G	604	142	648	178	163	
8-25-2006	35A-18G	604	194	765	179	164	
8-28-2007	25A-18G	610	168	1,070	21	6	Error in survey depth
9-9-2008	35A-18G	604	254	915	174	159	
9-22-2009	25A-18G	610	122	600	178	163	Sand fill at top of slots
9-14-2010	25A-18G	610	175	730	175	160	
10-29-2010	25A-18G	610	170	730	170	155	no offset interference

With the exception of the 8-28-2007 FOT, which is suspected to have an incorrect reported hang depth, the results of the FOTs show that the Tulare zone pressure has not varied more than 10 psi over the past 11 years. In particular, the most recent FOT in well 25A-18G showed the static formation pressure at 155 psig (datum depth of 730 feet) which is the exact same static pressure recorded 11 years earlier in well 45WS-18G (at an equivalent datum depth). With no evidence of an increased pressure level in the Tulare injection formation to-date, it is not expected that continued wastewater injection into the permitting wells will cause over-pressuring and/or breaches in the target injection formation over the next 10 years.

The FOTs can also provide information about the physical characteristics of the injection matrix and the presence of any near wellbore damage in the injection well. The following table presents this information interpreted from the FOTs conducted since 2005.

Summary of FOT Results for Permitting Wells								
Falloff Test Date	Well	Pre-FOT Injection Rate Bbl/day	Est. Perm. md	Perm-Thickness Kh md-ft	Skin Factor	Injecting BHP psia	Static Formation Pressure psia	ΔP, psi
5-4-2005	35A-18G	11,900	2,004	1,002,000	1.0	151	142	9
8-25-2006	35A-18G	14,250	1,695	474,600	14.2	264	194	70
8-28-2007	25A-18G	1,413	2,233	558,250	22.7	175	168	7
9-9-2008	35A-18G	4,900	3,040	851,200	33.2	280	254	26
9-22-2009	25A-18G	3,360	1,829	3,658	(5.3)	395	122	273
9-14-2010	25A-18G	5,140	2,396	534,308	43.0	226	175	51
10-29-2010	25A-18G	9,850	2,345	522,935	51.7	292	170	122

The recent FOTs for wells 25A-18G and 35A-18G determined high skin factors during the tests, evidence of near wellbore damage. The nature of this damage is unknown although it may be related plugging of the liner slots with fines. These wells tend to fill up with sand and silt particles over time and the wellbores occasionally need to be cleaned out back to their total depth.

The annual Pressure Fall-off and Mechanical Integrity Test procedure (**Exhibit I-1**) includes a plan to verify that the slotted liner completions in the permitting UIC wells are not plugged by fill material. Prior to commencing the test procedure, the fill level is determined by running in hole with sinker bars on slickline and tagging bottom. The well/s will be cleaned out as needed. All permitting wells will be tested in this manner at the time of the annual falloff test. For time periods between the annual fall-off tests, the UIC wells are monitored through Hall Plots and continuous wellhead pressure readings (see **Attachment H**, Operating Data and **Exhibit H-5**). If there is an indication of plugging in a well as evidenced by an increasing wellhead pressure, the procedure for tagging bottom and cleaning out fill material will be followed, at that time, as described in the annual falloff test procedure.

Radioactive Tracer Survey

A RTS will be run in each injection well on an annual basis to demonstrate the well's mechanical integrity for the tubing and packer and to ensure that injected fluid is moving into the injection zone only. The purpose is to show that there are no significant leaks in the tubing string and/or around the packer. A temperature recording tool will accompany the RTS logging tool. The injection rate will be as close to the maximum injection rate as practical during the survey. For the RA log runs, two RA detectors will be run in tandem to allow for volumetric flow measurements, injection zone flow profiling, and logging clock-timed observation for vertical flow. The temperature and RA data obtained from the surveys will be submitted electronically in addition to the hard copy logs.

Formation Fracture Pressure

A step rate test (SRT) to estimate the formation parting pressure (FPP) was conducted for injection well 35-18G on July 18, 2003. Surface and bottomhole injection pressures were recorded for a series of increasing injection rates (10 rates). The results and analysis of the SRT are presented by **Exhibit I-2**. An electronic copy of the SRT data is included on a CD-ROM with this application.

Exhibit I-2 is a graph of the bottomhole injection pressure at the end of each rate plotted versus the injection rate. There is no break in a line segment drawn through the data points which indicates that the FPP was not reached during the test. The test ended at a maximum injection rate of 384 gallons per minute and a surface pressure of 248 psi (521 psi bottomhole pressure). The conclusion from this SRT is that the surface injection pressure will have to be greater than 248 psi before the injection will fracture the formation.

For this UIC permit re-application, EHP proposes that the Maximum Surface Injection Pressure (MSIP) be set at 80 percent of the highest corresponding bottomhole pressure conditions obtained from the July 2003 step rate test that did not exceed the formation parting pressure (80% of 248 psig = 198 psig). The 80 percent limit is consistent with current EPA Region 9 policy. This MSIP of 198 psig would apply to all wells in this application.

The permitting injection wells are capable of operating at a surface wellhead injection pressures well below the 80 percent limit. The surface injection pressure data for the permitting wells over the years since injection began are provided in **Exhibit H-5**. A graphical presentation of the surface wellhead pressures and rates versus time is given by **Exhibit H-3**. The maximum and average surface pressure trends from June through December of 2010 are shown in the tables on page 23 of the Permit Application **Attachment H**, Operating Data. Since 2004, wastewater from the plant has been disposed of principally in two wells, 25A-18G and 35A-18G. The following conclusions are based on the data in **Exhibit H-5** for the permitting wells:

> Well 25A – 18G: The average surface pressure of all of the injection-days through March 31, 2011 is 11.2 psig. During its operational history starting in January 2004, there are only a handful of surface pressures readings greater than 125 psig. These high pressures are not sustained and subsequent pressure readings return to zero or less than 75 psi. There is no trend in the surface pressure data over the operational history; however, the average surface pressure of the injection-days in 2010 increased to 20.6 psig.
>
> Well 35A – 18G: The average surface pressure of all of the injection-days through March 31, 2011 is 6.6 psig. During its operational history starting in January 2004, there are only a handful of surface pressures readings greater than 125 psig. These high pressures are not sustained and subsequent pressure readings returned to zero or less than 75 psi. There is no trend in the surface pressure data over the operational history; however, the average surface pressure of the injection-days in 2010 increased to 47.2 psig.

Well 35 – 18G: The average surface pressure of the injection-days through March 31, 2011 is 89.5 psig. This well has a history of high surface injection pressures (150-190 psig) especially during 2003 when it was on full time injection. Since the construction of wells 25A-18G and 35A-18G in January 2004, well 35-18G has been retired from general use as an injection well.

Formation Matrix Information

Other injection formation matrix information may be determined, as requested by the EPA, through the well logs conducted on March 24, 2002 during the construction of well 35-18G. The logs are included with this application as **Exhibit I-3**.

Formation Water Samples

The Tulare formation fluid was not sampled in any of the four injection wells constructed by EHP; however, a Tulare water sample was collected in December 2008 from a well approximately two miles away in Section 14B. The fluid sample from 2282-14B source well was analyzed for constituents and other physical characteristics. The NACL salinity of this water sample was analyzed as 1,900 mg/L (ppm). The analysis from BC Laboratories is presented in **Exhibit I-4**.

The Tulare Zone water sample collected and analyzed in December 2008 from water source well 2282WS-14B is considered a representative sample of the original formation water in the vicinity of the permitting wells for the following reasons:

a) Well 2282WS-14B is approximately 1.5 miles west-northwest from the permitted well site which is outside of the calculated waste front and far enough away to be free of any endangering influence from the historical water injection volumes;

b) Well 2282WS-14B is on the same geological structure as the permitting wells and the Tulare zone is continuous across the area between well 2282WS-14B and the permitting wells;

c) The water sample is current in time having been collected at the end of 2008;

d) The TDS of the water sample is 3,500 mg/L, which is in line with the TDS measurements of other Tulare water samples in the area (as reported in **Exhibit A-1**). For example, the TDS concentration of a Tulare zone water sample, collected from the Elk Hills 33S Produced Water Plant in August 1998, was 4,692 mg/l. This water sample comprised commingled Tulare water sourced from wells in sections 18G, 13B, and 14B); and,

e) The results of the salinity (900 to 2,400 ppm) calculated from the SP log for well 25-18G are in good agreement with NaCl salinity reported by the laboratory analysis of the 2282WS-14B Tulare water sample (1,900 mg/L or ppm). The analytical laboratory report is presented in **Exhibit I-4** in the Permit Application. The formation water resistivity was obtained from the readings of the SP log. The salinity calculations are discussed in **Attachment I,** Formation Testing Program.

For comparison with the EHP project area, the salinity of the Tulare formation water was estimated from the open hole wireline logs for well 25-18G (March 2002). The salinity was estimated by calculating the resistivity of the formation water and cross-plotting the resistivity with the formation temperature using Schlumberger chart GEN 6 (Schlumberger, 2005). The formation water resistivity is obtained from the readings of the Spontaneous Potential (SP) log. The salinity calculations are presented in **Exhibit I-5**.

The results of the salinity calculated from the SP log for well 25-18G ranges from 900 to 2,400 ppm with an average salinity of 1,140 ppm for the upper section of the Tulare formation and an average salinity of 1,812 ppm for the lower Tulare section. These values are in close agreement with the NACL salinity (1,900 ppm) measured by the lab for the Tulare formation sample in well 2282-14B.

ATTACHMENT J – STIMULATION PROGRAM

Instructions

Outline any proposed stimulation program for the injection wells.

Stimulation Program

No stimulation treatment is expected to be necessary for the Tulare injection zone. The two main injection wells, 25A-18G and 35A-18G, currently take the disposal water on a vacuum or at a low surface pressure generally less than 25 psi. If it is ever needed, the injection wells may be stimulated using an acid treatment. A typical acid treatment, previously designed for injection well 25-18G is presented in **Exhibit J-1**.

ATTACHMENT K – INJECTION PROCEDURES

Instructions

This attachment is intended to describe the proposed injection procedures including pump, surge tank, etc.

Procedures

Injection of waste water into the injection wells is automated; the control narrative for the waste water disposal is provided in **Exhibit K-1**.

ATTACHMENT L – CONSTRUCTION PROCEDURES

Instructions

This section describes the procedures by which the wells were constructed. Included is available documentation of the drilling, coring, logging, and/or testing conducted, as well as the casing used and associated cementing procedures.

35-18G Construction

Well 35-18G was spudded on March 22, 2002 and was drilled to a total depth of 1800 feet below KB (12 feet above ground level), with an effective depth of 1795 feet KB. Documentation for Well 35-18G is given in **Exhibit L-1**.

The top Tulare clay interval was encountered at a depth of 600 feet KB and the base Tulare clay was encountered at a depth of 704 feet KB. The Tulare injection interval is from 704 to 1795 feet KB.

The downhole survey was completed on March 25, 2002.

Well construction comprised a 13-3/8" conductor landed at approximately 100 feet below KB, 8-5/8" casing landed at approximately 1800 feet KB (blank from the surface to 650 feet KB, and slotted with 24 rows x 2" slots x 6" centers x 200M from 650 feet KB to the bottom), and a 5" injection string with a hydraulic-set packer (top at 642 feet KB, tail at 648 feet KB).

The 8-5/8" casing was cemented from 680 feet KB to the surface with 920 cubic feet (cf) Type III cement with 2 percent $CaCl_2$, mixed at 14.8 pounds per gallon (ppg). Approximately 45 barrels (bbls) of good cement returned to surface. Well 35-18G was completed on April 24, 2002.

Well Logs and Tests

An Array Induction/GR/SP Density/Neutron/Mcfl log was run on March 24, 2002 from a depth of 100 feet KB to 1798 feet KB.

A Neutron-CCL Cement Bond Log was run on April 19, 2002 from the surface to a depth of 668 feet below KB.

A casing test was run on April 22, 2002. A water injection survey was run on September 10, 2008.

25-18G Construction

Well 25-18G has been plugged and abandoned; the plugging and abandonment was conducted in September 2010.

Well 25-18G was spudded on March 15, 2002 and was drilled to a total depth of 1760 feet below KB (12 feet above ground level). Well construction records are provided in **Exhibit L-2**.

The top Tulare clay interval was encountered at a depth of 629 feet KB and the base Tulare clay was encountered at a depth of 724 feet KB. The Tulare injection interval is from 724 to 1746 feet KB. The downhole survey was completed on March 18, 2002.

Well construction included a 13-3/8" conductor landed at approximately 100 feet below KB, a 8-5/8" casing landed at approximately 1760 feet KB (blank from the surface to 720 feet KB, slotted with 24 rows x 2" slots x 6" centers x 200M from 720 to 1745 feet KB, and blank from 1745 to 1760 feet KB), and a 5" injection string with hydraulic-set packer (tail at 672 feet KB).

The 8-5/8" casing was cemented from 1760 to 350 feet KB (top of concrete taken from Cement Bond Log) with 750 cf Type III cement with 2 percent CaCl2, mixed at 14.2 ppg. Approximately 34 bbls cement returned to surface. Well 25-18G was completed on April 19, 2002.

Well Logs and Tests

An Array Induction/GR/SP Density/Neutron/Mcfl log was run on March 18, 2002 from a depth of 100 feet KB to 1754 feet KB. A Formation Log was run from March 15 to March 18, 2002.

Plugging and Abandonment

Well 25-18G was plugged on September 21, 2010 with two cement plugs: from 900 feet KB to 371 feet KB with 195 cf Class A cement with 2 percent CaCl2, and from 371 KB to 17 feet KB with 129 cf 50/50 Class A cement with 2 percent bentonite/POZMIX. DOGGR inspected and approved the abandonment on September 22, 2010.

25A-18G Construction

Well 25A-18G was spudded on December 12, 2003 and was drilled to a total depth of 1424 feet below KB (10 feet above ground level), with an effective depth of 1420 feet KB. Well construction records are given in **Exhibit L-3**.

Well construction comprised: a 13-3/8" conductor landed at approximately 100 feet below KB; 8-5/8" casing landed at 715 feet KB; 5-1/2" casing foamed in to 1419 feet KB (perforated with 24 rows x 2" slots x 6" centers x 200M from 1415 to 724 feet KB, and blank from 724 to 684 feet KB); adapter, packer, and seal nipple from 684 to 670 feet KB (packer from 682 to 675 feet KB); and 5" blank casing from 670 feet KB to surface.

The 8-5/8" casing was cemented to surface with a lead slurry of 350 sacks Premium Plus cement, followed by a tail slurry of 125 sacks Premium Plus cement. Sixty bbls cement returned to surface. Well 25A-18G was completed on December 18, 2003.

Well Logs and Tests

A single shot survey was run at 715 feet KB.

35A-18G Construction

Well 35A-18G was spudded on December 18, 2003 and was drilled to a total depth of 1298 feet below KB (10 feet above ground level), with an effective depth of 1420 feet KB. Well construction records are provided in **Exhibit L-4**.

Well construction comprised: a 13-3/8" conductor landed at approximately 100 feet below KB; 8-5/8" casing landed at 715 feet KB; 5-1/2" casing foamed in to 1294 feet KB (perforated with 24 rows x 2" slots x 6" centers x 200M from 1289 to 648 feet KB, and blank from 648 to 610 feet KB); adapter, packer, and seal nipple from 610 feet KB to 597 feet KB (packer from 608 to 602 feet KB); and 5" blank casing from 597 feet KB to surface.

The 8-5/8" casing was cemented to surface with a lead slurry of 350 sacks Premium Plus cement, followed by a tail slurry of 125 sacks Premium Plus cement. 60 bbls cement returned to surface. Well 35A-18G was completed on December 24, 2003.

<u>Well Logs and Tests</u>

A single shot survey was run at 718 feet KB.

ATTACHMENT M – CONSTRUCTION DETAILS

Instructions

In addition to the construction procedures discussed in **Attachment L**, there is a requirement for a schematic or other appropriate drawings of the surface and subsurface construction details of the well or wells. This is comparable to a wellbore diagram of the completed well showing the end result for casing, tubing, perforations and cement.

Procedures

Schematic diagrams of the three permitting injection wells are presented in **Exhibit M-1**.

ATTACHMENT N – CHANGES IN INJECTED FLUID

Class III wells only – not applicable to this application

ATTACHMENT O – PLANS FOR WELL FAILURES

Instructions

This attachment is used to discuss the contingency plans in the event of a failure of an injection well to perform as permitted. These plans address the steps to ensure that injection fluids will not migrate into any USDWs.

Contingency Options

There are three injection wells being permitted with this application. This provides a great deal of flexibility with respect to ongoing well operations. If an injection well goes down, the first step will be to divert the wastewater disposal from the failed well to one or two of the remaining injection wells. Generally, each available well is capable of receiving all or a significant portion of the normal disposal volumes.

If the injectivity must be reduced further, the second step would involve curtailment of the wastewater production until the well or wells can be brought back on line. Finally, in the event of a catastrophic failure of all three injection wells, there is some limited onsite storage capability for the wastewater. However, if this unusual situation should ever occur, a plant shutdown would have to be initiated once the injection system was completely compromised.

In any case, there is no possibility in the event of a well failure that injection fluids will migrate into a USDW because there are no USDWs within approximately 5 miles of the location of the injection wells (see **Exhibit D-1**).

ATTACHMENT P – MONITORING PROGRAM

Instructions

As provided by 40 CFR 146.13, monitoring requirements shall, at a minimum, include: (1) The analysis of the injected fluids with sufficient frequency to yield representative data of their characteristics; (2) Installation and use of continuous recording devices to monitor injection pressure, flow rate and volume, and the pressure on the annulus between the tubing and the long string of casing; (3) A demonstration of mechanical integrity pursuant to Part 146.8 at least once every five years during the life of the well; and (4) The type, number and location of wells within the area of review to be used to monitor any migration of fluids into and pressure in the underground sources of drinking water, the parameters to be measured and the frequency of monitoring.

Quarterly reporting requirements include: (i) the physical, chemical and other relevant characteristics of injection fluids; (ii) monthly average, maximum and minimum values for injection pressure, flow rate and volume, and annular pressure; and (iii) the results of monitoring prescribed above.

The program should include monitoring the pressure buildup in the injection zone annually, including at a minimum, a shutdown of the well for a time sufficient to conduct a valid observation of the pressure fall-off curve.

Quarterly Reporting

The disposal wells are equipped with pressure and rate monitoring devices that allow for continuous recording of the injection pressure and injection rate. The minimum, maximum, and monthly averages of injection pressure and annular pressure will be submitted in quarterly reports. In addition, the flow rate and volume of injectate will be monitored and reported to the EPA on a quarterly schedule. The flow rate will be measured in the supply line immediately before the wellhead. All monitoring equipment shall be calibrated and maintained on a regular basis to ensure proper working order of all equipment. The monitoring program will maintain all the information previously prepared to meet the requirements of UIC Permit No. CA200002.

The monitoring program will include sampling the injectate on a quarterly schedule and testing the fluid for CAM metals, geochemical constituents and associated physical data, volatile organic compounds, semi-volatile organic compounds, corrosivity, and toxicity, the results of which will be reported to the EPA on a quarterly schedule.

Procedures followed for injectate sampling and analysis are described in Section 9.03 E1 of the Elk Hills Power Policies and Procedures Manual (**Exhibit P-1**).

Annual Well Logging and Testing

To ensure that the injected wastewater is moving into the injection zone only, an annual logging program will be conducted. Temperature and natural radioactive logs will be run to evaluate possible fluid migration above the casing shoe or around the packer. The results of the well logging program for the past five years is shown in **Exhibit P-2** for injection wells 25A-18G, 35-18G, and 35A-18G. The logs show no evidence of fluid migration around or above the packer.

A pressure falloff test will be conducted annually to evaluate the pressure buildup in the injection zone. The results of previous falloff tests conducted to measure the static formation pressure are discussed in **Attachment I**.

Mechanical Integrity Testing

Mechanical integrity tests (RTS method) to demonstrate the absence of significant leaks in the tubing and packer will be conducted annually on the three injection wells. Mechanical integrity of the casing will be investigated every five years using Standard Annulus Pressure Testing (SAPT) or after well reworks. Test results will be included in the next quarterly monitoring report.

ATTACHMENT Q – PLUGGING AND ABANDONMENT PLAN

Instructions

The plan for plugging and abandonment of an injection well must include a description of: (1) the type, number and placement (including the elevation of the top and bottom) of plugs to be used, (2) the type, grade and quantity of cement to be used, and (3) the method used to place plugs including the method used to place the well in a state of static equilibrium prior to placement of the plugs.

Plugging and Abandonment Program

Upon completion of injection activities, injection wells will be plugged and abandoned according to the rules and regulations of the DOGGR and EPA procedures. Plugging and abandonment plans will be modeled after the procedures presented in **Exhibit Q-1**, which is the plugging and abandonment plan for injection well 25-18G. The exact depths of the plugs and abandonment procedures will be determined at the time of the notice of intention to abandon well. The actual abandonment history for well 25-18G is given in **Exhibit Q-2**. This is the final approval from the DOGGR.

ATTACHMENT R – NECESSARY RESOURCES

Instructions

Evidence must be submitted to verify that the financial resources are available to close, plug and/or abandon the permitting wells.

Financial Statement

A financial statement verifying that resources necessary to plug or abandon the wells are available is presented in **Exhibit R-1**.

ATTACHMENT S – AQUIFER EXEMPTIONS

No aquifer exemption is requested.

ATTACHMENT T – EXISTING EPA PERMITS

Instructions

List program and permit number of any existing EPA permits, for example, NPDES, PSD, RCRA, etc.

Existing Permits

Elk Hills Power has two current EPA permits for its Elk Hills Power Plant:

Underground Injection Control Program, Class I Nonhazardous Waste Injection, Permit No. CA200002, Well Names: 25-18G, 35-18G, 25A-18G, and 35A-18G, Kern County, California, original permit issued February 21, 2001; modified June 3, 2004 (**Exhibit T-1**).

Authority to Construct, Issued pursuant to Prevention of Significant Deterioration Requirements at CFR 52.21, PSD Permit No. SJ-99-02, issued January 12, 2006 (**Exhibit T-2**).

ATTACHMENT U – DESCRIPTION OF BUSINESS

Instructions

Give a brief description of the nature of the business.

Description of Business

The EHP facility is a 550 megawatt, natural gas-fired, combined cycle facility. It was designed and constructed to generate electricity for about 420,000 homes in the Kern County area. The power plant consists of two combustion turbine generators, two heat recovery steam generators and exhaust stacks, and one steam turbine. It was a joint venture between Sempra Energy Resources and Occidental Energy Ventures of Elk Hills. The plant is presently owned by OEHI. The power facility was declared online and fully operational on July 23, 2003.

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